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Amendment of the claims under Article 19(1)

CLAIMS

1. (Amended) A flexible printed circuit board having a copper thin film made of copper or an alloy containing primarily copper and directly formed on at least one side of a plastic film substrate, wherein

said copper thin film has a two-layer structure comprising a surface layer having a crystalline structure and a bottom layer having a polycrystalline structure formed between said surface layer and said plastic film substrate,

said copper thin film has an X-ray diffraction pattern in which an X-ray relative intensity ratio (200)/(111), that is a valued obtained by dividing a peak intensity of the crystal lattice plane index (200) by a peak intensity of the crystal lattice plane index (111), is 0.1 or less, and

said bottom layer is configured as such that functional groups are generated on said plastic film substrate through plasma processing using mixture gas containing nitrogen, thereby forming metal made of copper or an alloy containing primarily copper, and then said metal and atoms constituting said plastic film substrate

are chemically bonded.

2. (Amended) The flexible printed circuit board in accordance with claim 1, wherein said surface layer is composed of crystal grains having at least the crystal lattice plane index (111) and that said crystalline structure is a columnar structure.

3. (Amended) The flexible printed circuit board in accordance with claim 1, wherein said surface layer is composed of columnar crystal grains having at least the crystal lattice plane index (111) and that said crystal grains are formed into a cylindrical shape, a polygonal columnar shape or a shape of a mixture of these.

4. (Amended) The flexible printed circuit board in accordance with claim 1, wherein said surface layer is composed of columnar crystal grains having at least the crystal lattice plane index (111) and said crystal grains are formed into a needle shape so that the short-axis diameters thereof are gradually reduced toward the side of said bottom layer making contact with said plastic film substrate.

5. (Amended) The flexible printed circuit board

in accordance with claim 1, wherein the columnar crystal grains having the crystal lattice plane index (111) and constituting said surface layer have a plane of said crystal lattice plane index (111) to be arranged according to preferred orientation in parallel to the surface of said plastic film.

6. (Cancelled)

7. (Amended) A flexible printed circuit board comprising a copper thin film made of copper or an alloy containing primarily copper directly formed on at least one side of a plastic film substrate, and copper formed on said copper thin film by the electrolytic plating method, wherein

said copper thin film has a two-layer structure comprising a surface layer having a crystalline structure and a bottom layer having a polycrystalline structure formed between said surface layer and said plastic film substrate,

said surface layer is composed of crystal grains having at least the crystal lattice plane index (111) and the grain size of the short axis of said crystal grains is 20 nm to 80 nm, and

said bottom layer is configured as such that

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functional groups are generated on said plastic film substrate through plasma processing using mixture gas containing nitrogen, thereby forming metal made of copper or an alloy containing primarily copper, and then said metal and atoms constituting said plastic film substrate are chemically bonded.

8. (Cancelled)

9. (Amended) The flexible printed circuit board in accordance with claim 1 or claim 7, wherein said bottom layer has a spherical structure.

10. (Amended) A flexible printed circuit board comprising a copper thin film made of copper or an alloy containing primarily copper directly formed on at least one side of a plastic film substrate, and copper formed on said copper thin film by the electrolytic plating method, wherein

said copper thin film has a two-layer structure comprising a surface layer having a columnar crystalline structure and a bottom layer having a spherical polycrystalline structure formed between said surface layer and said plastic film substrate,

said bottom layer is configured as such that

functional groups are generated on said plastic film substrate through plasma processing using mixture gas containing nitrogen, thereby forming metal made of copper or an alloy containing primarily copper, and then said metal and atoms constituting said plastic film substrate are chemically bonded, and

the diameter of a crystal grain of the spherical crystalline structure of said bottom layer is made smaller than the short-axis diameter of a crystal grain of the columnar polycrystalline structure of said surface layer.

11. (Amended) A flexible printed circuit board comprising a copper thin film made of copper or an alloy containing primarily copper directly formed on at least one side of a plastic film substrate, and copper formed on said copper thin film by the electrolytic plating method, wherein

said copper thin film has a two-layer structure comprising a bottom layer making contact with said plastic film substrate and a surface layer formed on said bottom layer,

said bottom layer is configured as such that functional groups are generated on said plastic film substrate through plasma processing using mixture gas containing nitrogen, thereby forming metal made of copper

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or an alloy containing primarily copper, and then said metal and atoms constituting said plastic film substrate are chemically bonded, and

the fluctuation width of the irregular face on the boundary face between said plastic film substrate and said bottom layer is in the range of 0.5 nm to 10 nm.

12. (Amended) The flexible printed circuit board in accordance with claim 11, wherein said bottom layer has polycrystals.

13. (Amended) The flexible printed circuit board in accordance with claim 9, 10 or 11, wherein said bottom layer has a spherical structure having a diameter of 10 nm to 80 nm.

14. (Amended) The flexible printed circuit board in accordance with claim 9, 10 or 11, wherein said bottom layer has a film thickness of 10 nm to 100 nm.

15. (Amended) The flexible printed circuit board in accordance with claim 1, 7, 10 or 11, wherein said copper thin film has a film thickness of 100 nm to 500 nm.

16. (Amended) The flexible printed circuit board

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in accordance with claim 10, wherein said surface layer is composed of crystal grains having the crystal lattice plane index (111).

17. (Amended) The flexible printed circuit board in accordance with claim 10, wherein the grain size of the short axis of the crystal grains having the crystal lattice plane index (111) and constituting said surface layer is 20 nm to 80 nm.

18. (Amended) The flexible printed circuit board in accordance with claim 10, wherein said surface layer is composed of crystal grains having at least the crystal lattice plane index (111) and said crystal grains are formed into a needle shape so that the short-axis diameter thereof is gradually reduced toward the side of said bottom layer making contact with said plastic film.

19. (Amended) The flexible printed circuit board in accordance with claim 18, wherein said surface layer is formed into a cylindrical shape, a polygonal columnar shape or a shape of a mixture of these.

20. (Amended) The flexible printed circuit board in accordance with claim 1, 7, 10 or 11, wherein said

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plastic film substrate is made of at least one material selected from among polyimide film, Teflon (registered trademark) and liquid crystal polymer.

21. (Amended) A method for producing a flexible printed circuit board comprising:

a step of subjecting a plastic film substrate to dewatering processing in vacuum,

a step of introducing a mixture gas containing nitrogen in vacuum,

a step of melting copper or a metal of an alloy containing primarily copper,

a step of generating glow discharge by applying high-frequency power to said plastic film substrate by using stable discharging means, and

an evaporation step of evaporating said metal to said plastic film substrate by ionizing said mixture gas and metal and by accelerating said ions by using a negative induced DC voltage generated by the glow discharge, wherein

at least nitrogen and argon are introduced at said evaporation step.

22. (Amended) A method for producing a flexible printed circuit board comprising:

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a step of subjecting a plastic film substrate to dewatering processing in vacuum,

a step of introducing a first mixture gas containing at least nitrogen, generating glow discharge by applying high-frequency power to said plastic film substrate by using stable discharging means and ionizing said first mixture gas,

a step of subjecting said plastic film substrate to plasma processing by using the first gas containing nitrogen ionized by the negative DC voltage induced in said plastic film substrate,

a step of subsequently melting a metal of copper or an alloy containing primarily copper in vacuum, generating glow discharge by using a second mixture gas containing argon and by applying high-frequency power to said plastic film substrate by using stable discharging means and ionizing said second mixture gas and said metal of copper or an alloy containing primarily copper, and

a step of evaporating a copper thin film onto said plastic film substrate by accelerating said ionized second mixture gas and metal grains of copper or an alloy containing primarily copper by using a negative DC voltage induced in said plastic film substrate.

23. (Amended) The method for producing a

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flexible printed circuit board in accordance with claim 21 or 22, wherein the step of subjecting said plastic film substrate to dewatering processing in vacuum includes a step of carrying out dewatering processing so that the partial pressure of moisture is 10^{-3} Pa or less.

24. (Amended) The method for producing a flexible printed circuit board in accordance with claim 22, wherein at the step of carrying out the plasma processing by using said first mixture gas containing at least nitrogen, the degree of vacuum is in the range of 10^{-3} Pa to 10^{-1} Pa, and said negative DC voltage induced in said plastic film substrate is 200 V to 1000 V.

25. (Amended) The method for producing a flexible printed circuit board in accordance with claim 22 or 24, wherein at the step of carrying out the plasma processing by using said first mixture gas containing at least nitrogen, said mixture gas contains nitrogen and an inert gas, the volumetric ratio of nitrogen in the entire gas being set at 50% to 99.99%.

26. (Amended) The method for producing a flexible printed circuit board in accordance with claim 21, wherein at the step of evaporating said metal on said

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plastic film substrate, said mixture gas containing nitrogen is a mixture gas containing nitrogen and an inert gas, the volumetric ratio of nitrogen in the entire gas being set at approximately 1% to approximately 20%.

27. (Amended) The method for producing a flexible printed circuit board in accordance with claim 21 or 22, wherein at the step of evaporating said metal on said plastic film substrate, the degree of vacuum is in the range of 10^{-3} Pa to 10^{-1} Pa, and said negative DC voltage induced in said plastic film substrate is 200 V to 1000 V.

28. (Amended) The method for producing a flexible printed circuit board in accordance with claim 21 or 22, wherein at the step of evaporating said metal on said plastic film substrate, a copper thin film having a film thickness of 10 nm to 100 nm is formed at an evaporation speed of 0.1 nm/sec to 0.5 nm/sec in the early stage of the evaporation, and film-forming is carried out subsequently at an evaporation speed of 0.5 nm/sec to 10 nm/sec so that the total film thickness of said copper thin film is 100 nm to 500 nm.

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Explanation in accordance with Article 19 (1) of the Convention

We have amended claim 1 to clearly describe the content of the present invention in conformity with the description of the specification.

We have amended claims 4 and 18 to clearly describe the present invention by specifically define the description of "needle shape".

We have amended claims 7 and 17 in conformity with the description of the specification.

We have amended claims 10 and 11 to clearly describe the content of the present invention in conformity with the description of the specification.

We have amended claim 22 to clearly describe the content of the present invention by classifying the mixture gas.

We have amended claim 25 by canceling the wording "approximate" and amending the definition of the mixture gas in conformity with the description of the specification.

We have further amended claims 1, 7, 10 and 11 so as to clarify the present invention and thereby to distinctively describe the difference from the cited references by adding the phrase "said bottom layer is configured as such that functional groups are generated on said plastic film substrate through plasma processing using mixture gas containing nitrogen, thereby forming metal made of copper

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or an alloy containing primarily copper, and then said metal and atoms constituting said plastic film substrate are chemically bonded".